



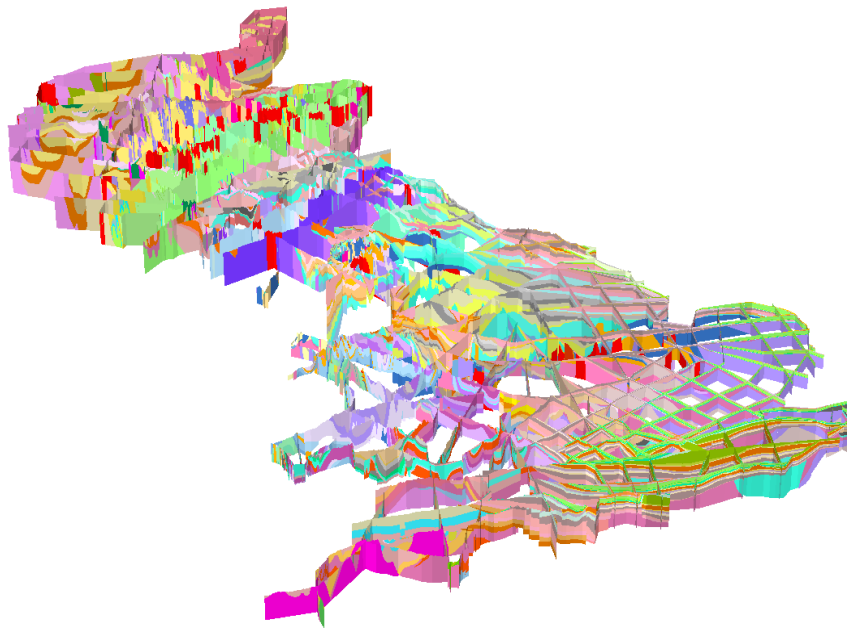
**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Metadata report for the National Bedrock Fence Diagram GB3D_v2012.

Geology and Landscape Programme

BGS Open Report OR/12/079



Metadata report for National Bedrock Fence Diagram GB3D_v2012

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Front cover The GB3D fence diagram in 2012 with some sections removed in Scotland to improve clarity

Frontispiece The distribution of the Grey Chalk sub-group in southeast England as revealed by its outcrop and distribution in cross-sections

Bibliographical reference

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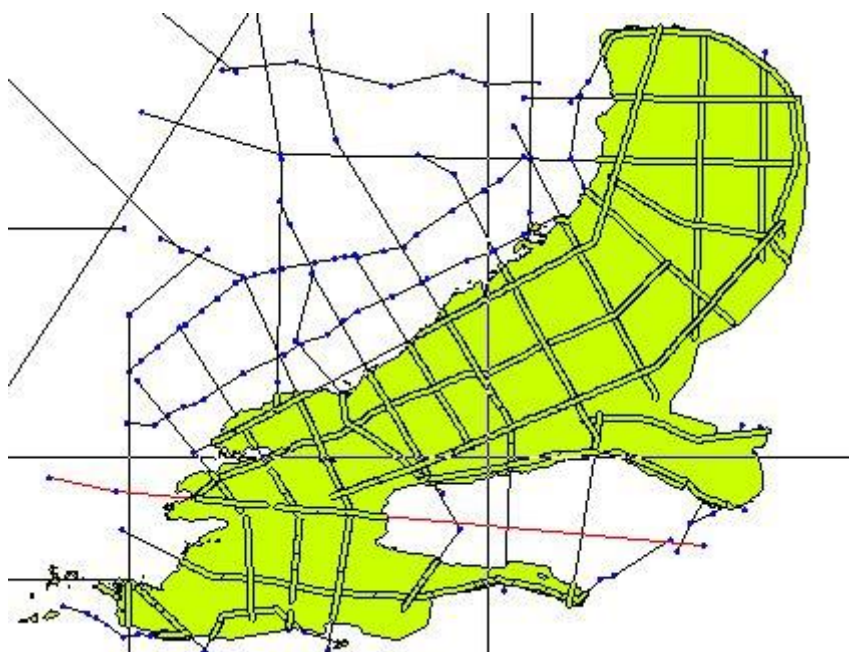
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Maps and diagrams in this book use topography based on Ordnance Survey mapping.

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Summary

This report describes the 2012 version of the GB3D National Bedrock Fence Diagram produced by a mixture of EA funded contracts and BGS National Capability projects between 2009-12. The fence diagram, comprising the GB3D_v2012 dataset, is the subject of this report and is now available in a variety of formats from the BGS website as free downloads. It complements the existing 1:625 000 scale mapsheets published recently utilising the same colour schema and geological classification. The fence diagram currently covers England, Wales, Scotland and the Isle of Man. It is envisaged that this dataset will form a useful educational resource for geoscience students and the general public and also provide the bedrock geology context and structure for national, regional, basin-wide and catchment scale studies.

This report follows a BGS format for the summary of key project metadata, however it is issued as an open report so that it can be provided as a companion to the model dataset where licensed in digital form or served as a free download via the BGS website. Further information about the dataset is available on request from <http://www.bgs.ac.uk/enquiries>.

1 Modelled volume, purpose and scale

The model covers the onshore area of Great Britain (England, Scotland and Wales) and the Isle of Man and comprises 121 cross-sections with a total linear length exceeding 20,000 km built to depths varying between 1.5 - 6 km. The initial build in 2009-10 covered England and Wales only and was funded by the Environment Agency of England and Wales (EA) Schofield et al. (2012).

In this early version of the model Superficial deposits thicker than 10m as indicated by the BGS national Rockhead Elevation Model (RHEM: Lawley & Garcia-Bajo, 2010) were shown classified into permeable, impermeable and mixed categories. Subsequent versions of the model have dealt only with the bedrock geology. For the purposes of this model the Plio-Pleistocene Crag Group deposits of East Anglia have been regarded as a bedrock unit. In 2010-12 the network of sections was extended to Scotland, densified in England and Wales and sections were aligned along the coast to give the overall fence diagram the familiar boundary of the British coastline and encourage future offshore extension. Sections in northern Scotland were continued across the Minch to the Outer Hebrides and similarly to Orkney, at present coverage has not been extended to include Shetland. In 2012 additional funding from the Environment Agency enabled a few additional sections to be inserted, whilst others were extended and/or deepened in key sedimentary basins as part of a project to design a risk screening tool for the possible impact on important aquifers of shale gas extraction (fracking).

The model seeks to be compatible with the geological linework of the 1:625 000 scale bedrock mapsheets, UK North and South (BGS 2007a; 2007b, Figure 1). Some of the detail on the mapsheets of faulting, minor intrusions and lithological variations within individual units have not been included in the cross-sections. The same stratigraphical schema has been followed and 341 units including intrusions and metamorphic suites are distinguished in the fence sections. The geology of the UK as portrayed on these mapsheets is described in two accompanying booklets (Jackson, 2008; Stone, 2008).

Within the two principle groundwater aquifers the Chalk Group and the Sherwood Sandstone Group additional stratigraphical detail ideally to formation level has been inserted wherever appropriate information was available at the request of the Environment Agency.

The sections have all been constructed in the GSI3D software with the aid of raster backdrops of both maps and sections derived from existing bedrock models at resolutions varying from 1 : 1 Million to 1:10 000. Additionally, short trimmed excerpts from sections depicted on the margins of the BGS 1:50 000 scale mapsheet series have been used to ensure that the geology depicted by the fence diagram is consistent with the map sections. Because of the difference in resolution of the two sets of sections and the variability in stratigraphical detail included in the 50K sections not all the unit intercepts could be used to guide the fence diagram sections. The overall result is a framework of sections that have been constructed intelligently by using the available data. As a result, the fence diagram should contain a high degree of spatial accuracy as it is keyed into many previous model, map and section interpretations themselves based on available data from deep boreholes and seismic lines.

The fence diagram units have been attributed with a variety of hydrogeological properties in England and Wales to create alternative ways of displaying the geology.

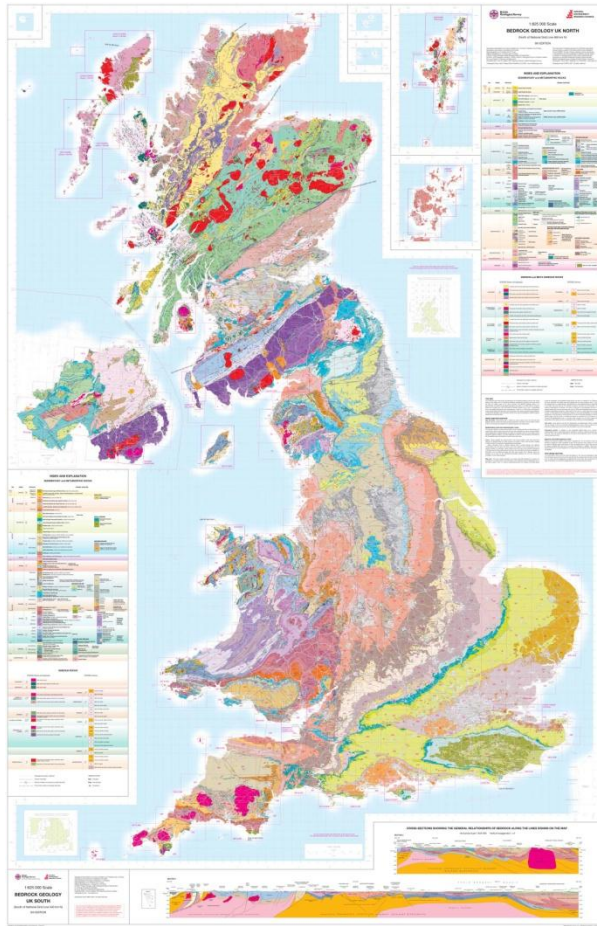


Figure 1. Printed version of the BGS 1:625 000 scale bedrock geological data combined from the two component mapsheets.

2 Modelled faults

In this first version of the fence diagram faults have not been included as an object type within the dataset. Major faults were however loaded into the workspace as an aide to drawing during section construction. So faults are simply shown by a break or offset in the geological units. It is envisaged that in future versions of the fence diagram regionally significant faults at an appropriate resolution will be included.

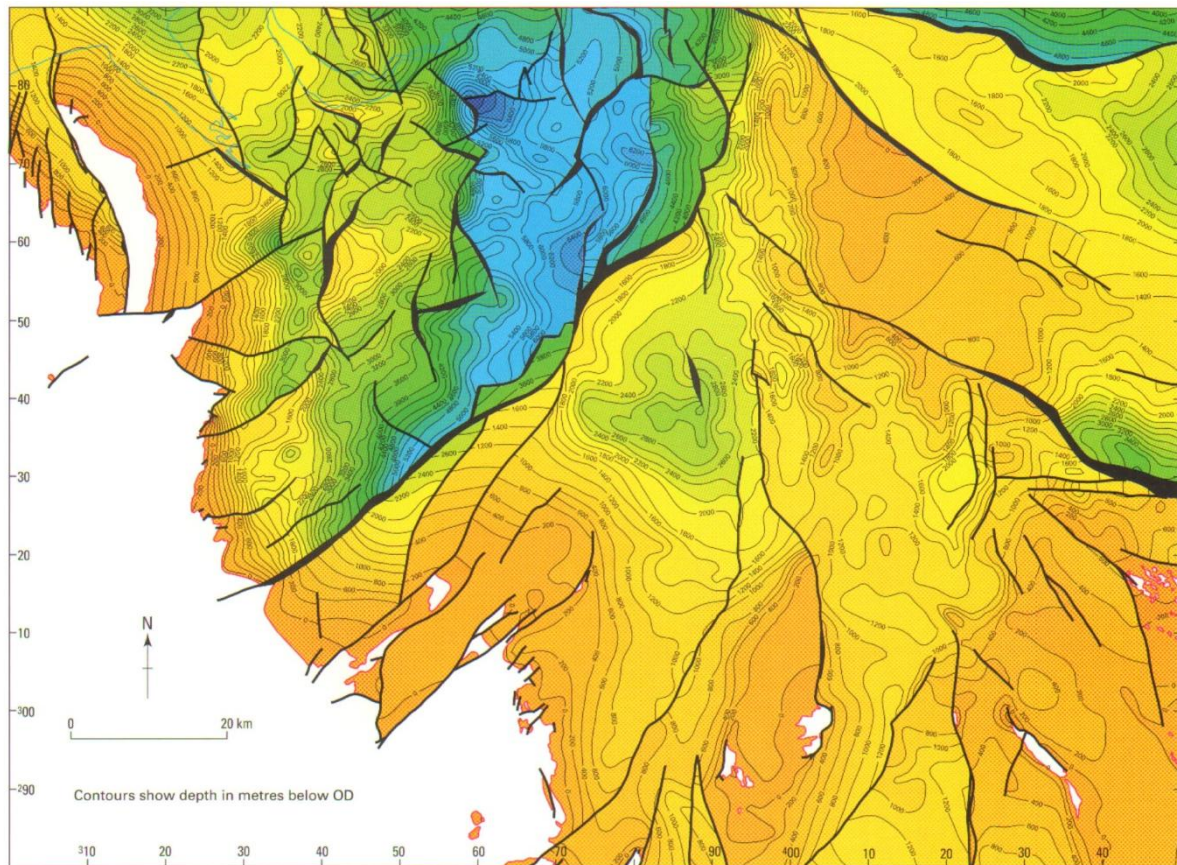
3 Model datasets

Each geologist on the project provided a list of spatial reference material that could be geo-referenced and used to constrain their sections. Each of these datasets were loaded into the map or section window of GSI3D so the geologist could use them as a guide in section construction. The list of material of sources used is contained in the spreadsheet at Appendix A.

Sources used include:

Structural contour plots at regional scale

Regional structure contour plots are mainly derived from the BGS Subsurface Memoir series and comprise essential syntheses of available deep borehole and interpreted seismic data for individual surfaces over wide areas (Figure 2).



Map 1 Depth to Caledonian unconformity.

Figure 2. Depth to Caledonian unconformity for the south-west Pennine Basin and adjacent area (from Smith, et al. 2005). Contours are in 200 m intervals and are offset by geological faults, shown as black lines where they intersect the unconformity. OS topography © Crown Copyright

Structural contour plots at local scale

Derived from the main BGS sheet memoir series and margins of 1:50 000 scale mapsheets these are similar in style to the regional plots and are also based on borehole and interpreted seismic data together where appropriate with outcrop information and mine plan data. Because of their restricted extent and context they are less useful for GB3D section construction at the intended resolution and stratigraphical detail of the fence diagram.

1:50 000 Map Sheet Cross-Sections

These sections exist as 3D shapefile parts that can be imported into GSI3D as short section segments to guide correlation where the GB3D sections cross them. They appear as colour-coded

cross ticks on the GB3D section with an attribute from the 1:50 000 scale LEX-RCS code that was incorporated into the overall legend used for the sections (Figure 3). Data from about 130 1:50 000 scale cross-sections were provided to guide the GB3D section construction.

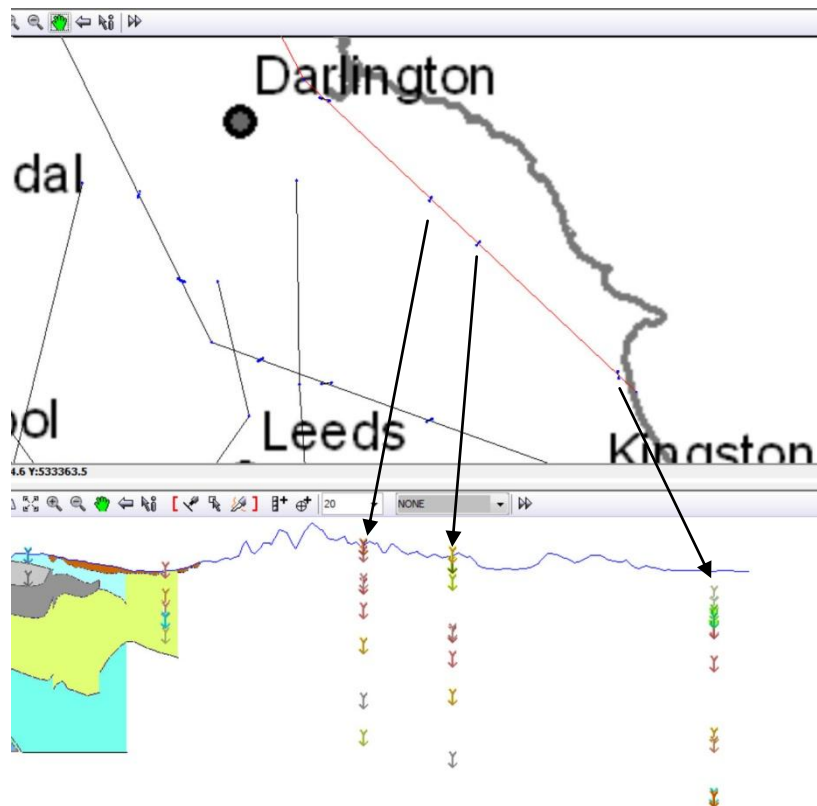


Figure 3. GB3D section shown in red in the map view (above) and under construction in section view showing cross ticks from 1:50 000 scale mapsheet section intersections as guides (below). NEXTMap Britain elevation data from Intermap Technologies

Examples of other datasets used include the Coal Resources Map of Britain, (Chapman, 1999) published jointly by the British Geological Survey and the Coal Authority

Published Cross-sections

Scale-true cross-sections were also used in the construction of the GB3D cross-sections. These were carefully georeferenced enabling the effects of any vertical exaggeration to be captured with the image. Then a GB3D regional section was constructed along the exact alignment of the published section which could then be rendered as a semi-transparent raster image backdrop in its correct geospatial position in the GSI3D section view. This enabled its use either for direct tracing or as a guide to the drawn geologist's interpretation.

Legacy BGS 3D Model Data

3D Model data was used in cross-section to guide the geologist's interpretations. Figure 4 shows the distribution of 3D geological models used to construct the GB3D sections. A shapefile with attribute information about each of these models is stored in the BGS Geoscience Data Index (GDI), this database is only available internally to BGS staff..

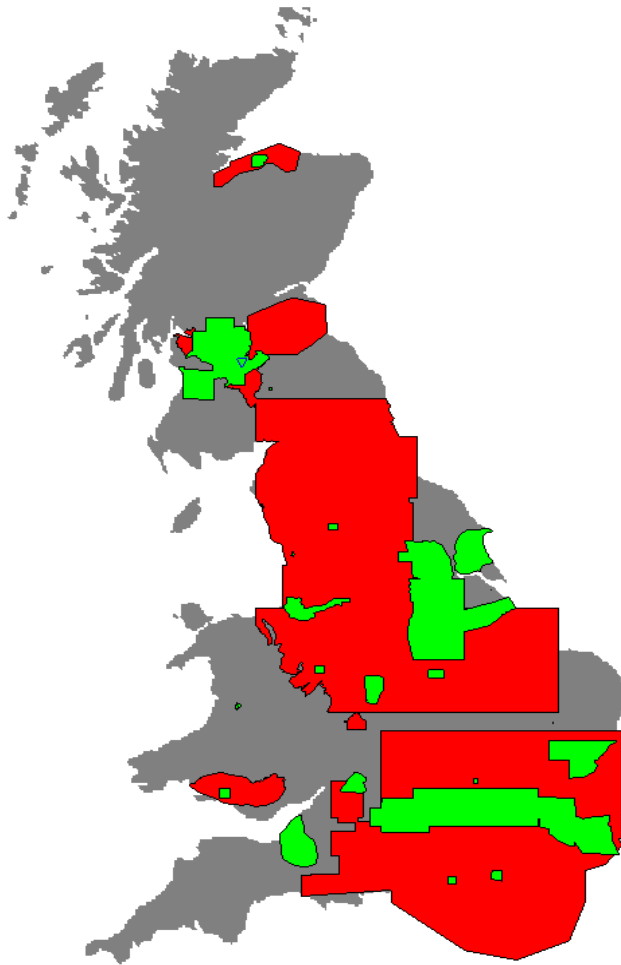


Figure 4. BGS 3D geological framework models at 2012, red shows regional and basin-scale models whereas the green areas contain more detailed shallower models. Green areas enclosed within larger red polygons usually contain models of both types.

The 3D model data would appear in the back-drop of a of a GB3D section as a series of labelled lines that the geologist would be able to use as a guide for correlation

Many of the surfaces from the 1Million scale model (Mathers et al. 2011) were too generalised and at too low resolution to be relied upon. Cuts through LithoFrame 250K resolution GOCAD models based on BGS subsurface memoir series of sedimentary basins in Northumberland-Solway, East Midlands, Southwest Pennines, Craven and Weald contributed useful detail. In addition more detailed 50,000 and 10,000 resolution GSI3D models, mainly located in the London Basin, southern East Anglia-Essex, Greater Manchester, Merseyside and York were utilised. These models are in the main shallow and so were only able to contribute information on the uppermost bedrock units. Details of the data utilised in the construction of these models is contained in the separate reports and metadata documentation of the individual models.

DTM

Initially prepared in 2009-10 from the licensed national NextMap 5 m coverage, sub-sampled with a variable grid spacing comprising 250 m along buffered section alignments and 2500 m in intervening areas. This was then replaced in 2011 with an overall NextMap coverage sub-sampled to 500 m due to the increase in the number of sections. This dataset also includes the Isle of Man SRTM (Shuttle Radar Topography Mission data) data at 75 m resolution.

Map data

The attributed digital shape file of the combined 1:625 000 scale bedrock geology maps (BGS 2007a; 2007b) was utilised to provide guidance on the surface outcrop pattern during section construction.

Seismic and Borehole data

Seismic and Borehole data have not been used directly in the construction of the fence diagram however these sources have been extensively utilised in the production of the various geological models that were displayed as a Geo-referenced raster backdrop of their interpretation along the fence section alignments. Where multiple resolution models were available the highest resolution model was used to guide the interpretation unless it was known to be less reliable.

4 Model development

The initial fence diagram delivered to the EA in 2010 is shown below at Figure 5, the alignment of sections in the GB3D_v2012 dataset is shown in Figure 6 and the GB3D_v2012 fence diagram is shown at Figure 7.

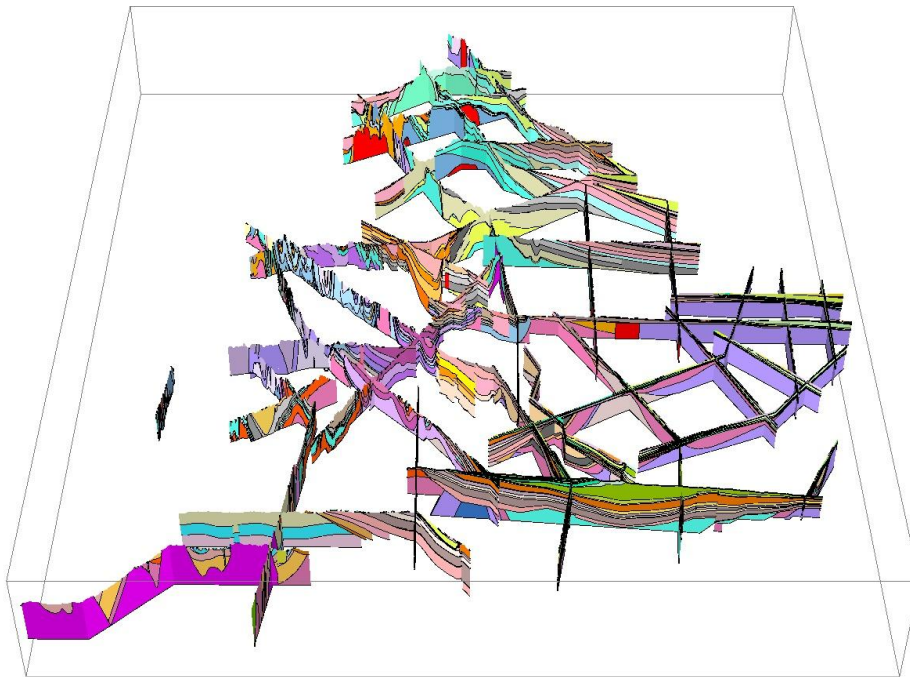


Figure 5. The fence diagram for England and Wales as delivered to the EA in 2010 (Schofield et al. 2012)



Figure 6. The completed network of cross-sections for the GB3D_v2012 dataset

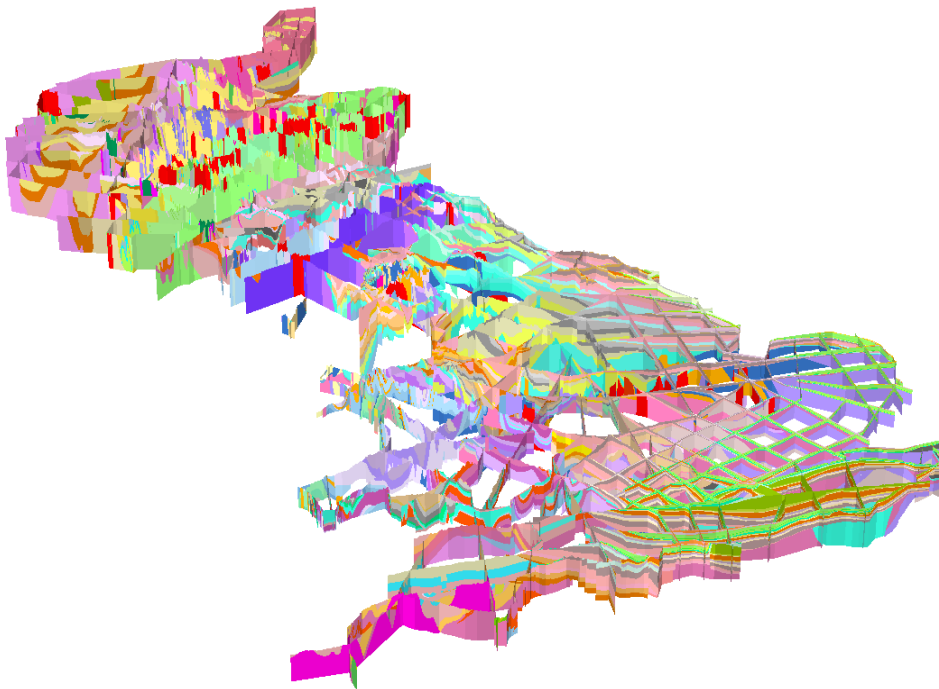


Figure 7. The completed GB3D_v2012 fence diagram

Sections were constructed by a team of geologists supported by data managers, the individual responsibilities for sections are summarised below:

Clive Auton *Moray, Caithness, Orkney and Shetland (from 2010)*

Graham Leslie *Highlands and Islands (from 2010) lead in Scotland*

Mike McCormac *Midland Valley (from 2010)*

Hugh Barron *Midland Valley and Southern Scotland (2010)*

Colin Waters *North and Northeast England, Wales and England-Wales Carboniferous and Permo-Trias (2009-12)*

Dick Crofts *Northwest England (until 2010)*

John Powell *Yorkshire and Northeast England coast (until 2010)*

Phil Wilby *Yorkshire & Lincs (until 2010)*

Mark Barron *Midlands and Jurassic (2009-12)*

Keith Ambrose *Midlands (until 2010)*

David Schofield *Wales and EA Project manager (2009-10)*

Peter Hopson *Southern England and Cretaceous (2009-12)*

Poul Strange *Southwest England (until 2010)*

Steve Mathers *Overall concept, East Anglia, London Basin, Palaeogene, Neogene EA 2012 iHydrogeology contract Manager of Work Package 1 (extension of fence diagram)*

Data management

Ricky Terrington *overall data and workflow management, methodology development (2009-12)*

Hannah Gow (nee Cullen) *Workspace preparation, data management (from 2010)*

Steve Thorpe *Workspace preparation, data management (from 2010)*

Ben Wood *GSI3D Software troubleshooting*

Holger Kessler *GSI3D Software troubleshooting*

Ian Cooke *Data management and editing*

Tony Myers *Data formatting and conversion*

In addition to the geological classification of the strata attributes have been assigned to the units by the following staff:

Millie Lewis and John Bloomfield Hydrogeology*

*Tasks co-funded as part of the EA 2012 iHydrogeology contract

5 Model workflow

A standard GSI3D workflow (Kessler & Mathers 2004; Kessler, Mathers & Sobisch, 2009) was followed for drawing the sections and constructing the distributions (outcrop and/or subcrop) of units. Calculated volumes have been produced from the sections for the units with simple geometry.

The project workflow for the EA project in 2009-10 is shown below as Figure 8.

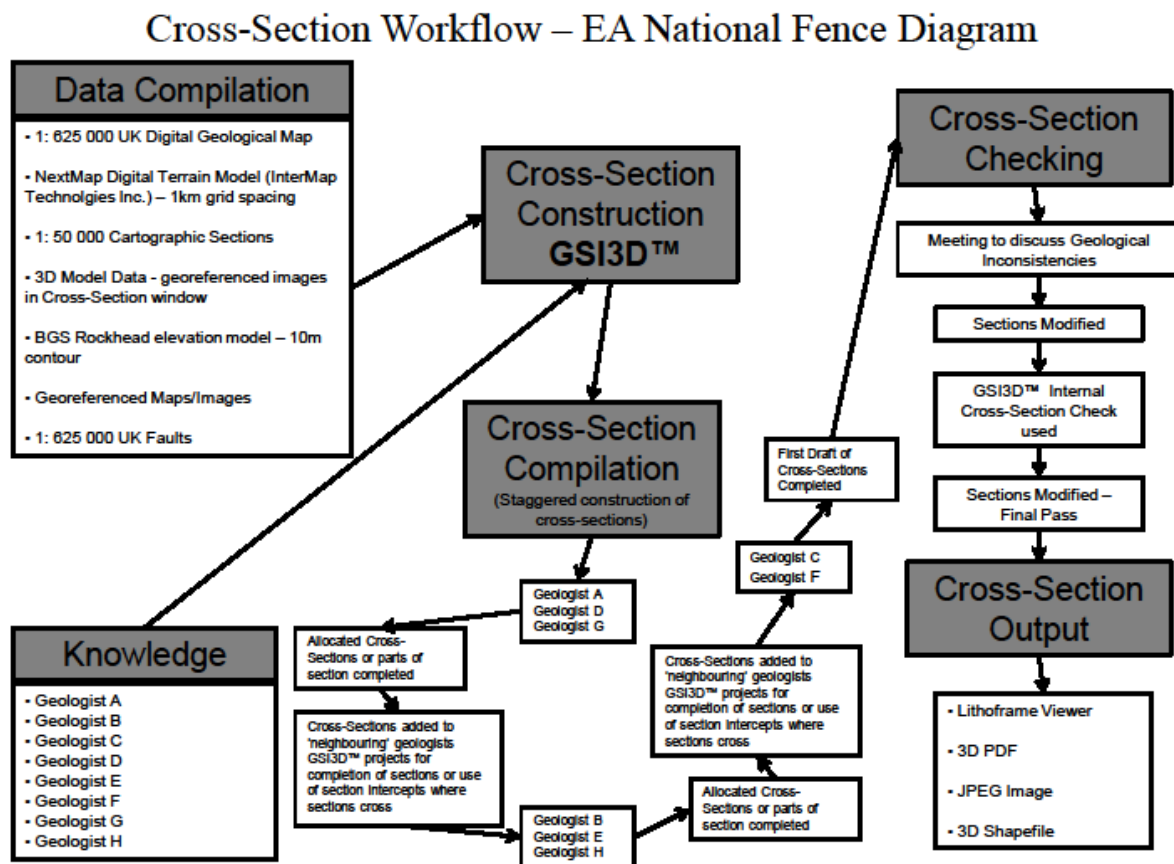


Figure 8. The project workflow for the initial EA contract 2009-10

From 2011 the complexity of the project and the need to maintain strict version control between a dozen or more geologists lead to changes in workspace construction and data management Gow & Terrington (2012).

This included the design and implementation of a section tracking database (GB3D Section Tracker) which recorded all changes to the cross-sections within the project. This database records changes made for each section by geologist, date, cross-section location and has a free text column for a description of changes made

6 Model assumptions, geological rules used etc

- Wherever possible the 1: 625 000 scale mapsheet linework, stratigraphy and rock classification scheme were adopted in the section construction. In practice it was necessary to simplify some of the detail in terms of minor intrusions, minor faults and lithological facies variations within individual units.
- Significant faults are depicted as offsets of the geology rather than as actual fault objects within the workspace

- Superficial geology is excluded from the upgraded set of sections from 2010. This implies that where superficial deposits are present the bedrock unit floods up to the DTM in sections. In general the thickness of superficial deposits is insignificant at the intended section resolution.
- The depth cut off is variable depending on the nature of geology, it is generally 1.5 - 3 km but lies deeper where major aquifers and potential mineral or hydrocarbon sources are present within sedimentary basins.
- A false horizontal base at an arbitrary depth has been constructed for some units to provide a base for the section, these should not be interpreted as true bases for these units

7 Model limitations

We recommend that this dataset should be used for:

- General and geosciences education to illustrate of national and regional British geology (from the available download)
- Illustrating national or regional bedrock geology overviews for scientific publications for widespread and/or non specialist use e.g. Radwaste (Powell et al. 2010) Shale Gas (Mathers et al. 2012a) with an Intended resolution of use in the 250K-1M range.
- Catchment-basin scale water management characterisation yielding first order calculated volumes based on unit coverages and cross section extents (calculation of dataset performed in GSI3D)
- Regional GIS projects including the extents (x,y) of individual geological units (generated for GIS in GSI3D)

We recommend that this dataset should not be used for:

- Detailed geological assessments of any kind, e.g. borehole, site or linear route prognosis, resource-reserve estimation and exploration of any kind and any representation or use outside the intended regional to national (250K-1M) resolution
- The dataset is provided as a free download in varied formats for educational and other not for profit uses. Further information about licensing the digital data for commercial usage is available on request from <http://www.bgs.ac.uk/enquiries>

8 Model uncertainty.

At present the fence diagram is not easy to assess in terms of uncertainty because it does not directly reflect the distribution of hard data utilised as this has occurred through intermediate models, maps, sections and reports.

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details).

The library catalogue is available at: <http://geolib.bgs.ac.uk>.

In recent years all NERC publications have been submitted for inclusion in the NERC Open Research Archive (NORA) details are at: nora.nerc.ac.uk/

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